

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method for detecting parallel arcing faults in a set of wires, the voltage at which a parallel arcing fault occurs being below a predetermined test voltage level, each parallel arcing fault producing emitted signals that include electromagnetic waveforms and ultrasonic emissions, the method comprising:

selecting a first wire of the set of wires and defining the first wire as a wire under test while grounding the remaining wires in the set of wires to define these remaining wires as ground wires;

charging a capacitance defined between the wire under test and the ground wires using a current source until the voltage on the wire under test ramps up to the predetermined test voltage level; and

calculating the distance to a parallel arcing fault on the wire under test by determining the difference in arrival times among two or more emitted signals.

2. The method of Claim 1, further comprising: receiving by two or more receivers two or more leading edges of the two or more electromagnetic waveforms that conduct along the wire under test, one receiver being located at one terminal of the wire under test and the other receiver being located at the other terminal of the wire under test, and wherein the act of calculating includes calculating the difference in the arrival time of one leading edge received at the one receiver and the arrival time of the other leading edge received at the other receiver.

3. The method of Claim 1, further comprising: receiving by two or more receivers two or more impulses of the two or more electromagnetic waveforms that radiate from the parallel arcing fault, and wherein the act of calculating includes calculating the difference in the arrival time of one impulse received at one receiver and the arrival time of the other impulse received at the other receiver.

4. The method of Claim 1, further comprising: receiving by a receiver both an impulse of one of the electromagnetic waveforms as well as an ultrasonic emission produced from the parallel arcing fault, and wherein the act of calculating includes

calculating the difference in the arrival time of the leading edge of the one of the electromagnetic waveforms and the ultrasonic emission.

5. The method of Claim 1, further comprising: iterating the act of selecting to select a second wire of the set of wires and defining the second wire as the wire under test while grounding the remaining wires including the first wire in the set of wires and defining the remaining wires including the first wire as ground wires, the act of iterating being executed for the act of charging and the act of calculating.

6. A system for detecting and locating parallel arcing faults in a set of wires, the voltage at which a parallel arcing fault occurs being below a predetermined test voltage level, each parallel arcing fault producing two or more electromagnetic waveforms and ultrasonic emissions, each electromagnetic waveform having a leading edge, the system comprising:

a first device coupled to the set of wires for applying a current to a wire under test while grounding the remaining wires of the set of wires so as to charge a capacitance defined between the wire under test and the remaining wires up to the predetermined testing voltage, the first device being adapted to locate the distance to the parallel arcing fault using one or more leading edges of one or more electromagnetic waveforms being conducted on the wire under test;

a second device for locating and calculating the distance to the parallel arcing fault, the second device being comprised of a controller and two or more receivers, each receiver being electrically coupled to the controller for receiving one or more leading edges of one or more electromagnetic waveforms being radiated by the parallel arcing fault; and

a third device for locating and calculating the distance to the parallel arcing fault, the third device being adapted to sense one or more leading edges of one or more electromagnetic waveforms as well as the ultrasonic emissions emitted from the parallel arcing fault.

7. The system of Claim 6, wherein the first device is a hand-held device being powered by a battery.

8. The system of Claim 6, wherein the first device includes a processor running a first piece of software for measuring the resistance of the insulation of the wire under test as well as the capacitance while the current is being applied to the wire under test.

9. The system of Claim 8, wherein the first device includes a display displaying the resistance of the insulation of the wire as well as the capacitance to the user.

10. The system of Claim 8, wherein the processor has a second piece of software for recording the voltage at which the parallel arcing fault occurs, the processor being adapted to switch to run the second piece of software from the first piece of software when the parallel arcing fault occurs.

11. The system of Claim 10, wherein the processor has a third piece of software for locating the parallel arcing fault, the processor being adapted to switch to run the third piece of software from the second piece of software when the voltage at which the parallel arcing fault occurs has been recorded.

12. The system of Claim 11, wherein the first device includes high-speed circuitry to receive and process one or more leading edges or one or more electromagnetic waveforms being conducted along the wire under test so as to determine the location of the parallel arcing fault.

13. The system of Claim 6, wherein the second device is a hand-held device being powered by a battery.

14. The system of Claim 6, wherein the two or more receivers of the second device are electrically coupled to the controller via two or more coaxial cables.

15. The system of Claim 6, wherein the third device is a hand-held device being powered by a battery.

16. A device for detecting and locating parallel arcing faults in a set of wires, the voltage at which a parallel arcing fault occurs being below a predetermined test

voltage level, each parallel arcing fault producing an incident waveform and a reflected waveform, each waveform having a pulse width, the device comprising:

a controller for receiving information and for processing the information to produce a number of control signals;

a current source having a first terminal coupled to the controller and a second terminal coupled to a first node, the current source being receptive to a first control signal from the controller at the first terminal to produce direct current at a level as indicated by the first control signal so as to charge a capacitance up to the predetermined testing voltage, the capacitance being defined between a wire under test and the remaining wires of the set of wires; and

a timing circuit having a first terminal coupled to the first node and a second terminal coupled to the controller, the timing circuit being receptive to the incident waveform and the reflected waveform at the first terminal so as to measure the pulse width of the incident waveform and the reflected waveform and produce at the second terminal a locating signal being proportional to the distance from the device to the parallel arcing fault.

17. The device of Claim 16, further comprising a user interface device coupled to the controller via a serial link, the user interface including a display for displaying information from the controller and a keyboard for inputting information into the controller.

18. The device of Claim 17, wherein the display is adapted to display the insulation resistance of the wire under test and the capacitance.

19. The device of Claim 16, wherein the current source includes a voltage switching supply to produce DC voltage proportional to the first control signal, the DC voltage being in the range of less than about 6000 volts, the current source including a resistor coupled to the voltage switching supply, the resistor being in the range of about 1 gigaohm.

20. The device of Claim 16, further comprising a voltage sensor for sensing a voltage level at the first node, the voltage sensor being comprised of a voltage divider.

21. The device of Claim 16, further comprising a first relay having a first terminal coupled to the controller for receiving a second control signal, a second terminal coupled to ground, and a third terminal coupled to the first node, the first relay being adapted to couple the first node to ground when the second control signal is at a first predetermined level and adapted to uncouple the first node from ground when the second control signal is at a second predetermined level.

22. The device of Claim 16, further comprising a sequencer for coupling the wire under test to the first node while grounding the remaining wires of the set of wires, the sequencer defining the wire under test as a previous wire under test when the device cannot detect the parallel arcing fault on the wire under test, the sequencer being adapted to choose another wire of the remaining wires of the set of wires and define the another wire as the wire under test while grounding the previous wire under test and the remaining wires.

23. The device of Claim 22, further comprising a second relay having a first terminal coupled to the controller for receiving a third control signal, a second terminal coupled to ground, and a third terminal coupled to the remaining wires of the sequencer, the second relay being adapted to couple the remaining wires to ground when the third control signal is at a first predetermined level and adapted to uncouple the remaining wires from ground when the third control signal is at a second predetermined level.

24. The device of Claim 16, wherein the timing circuit comprises:  
means for measuring the pulse width of the incident waveform and the reflected waveform, the pulse width being proportional to the time for the incident waveform or the reflected waveform to travel from the parallel arcing fault back to the device; and  
means for calculating the distance to the parallel arcing fault by multiplying the propagation speed in the wire under test by the pulse width of the incident waveform or the reflected waveform.

25. A method for detecting parallel arcing faults in a set of wires, each parallel arcing fault producing two or more electromagnetic waveforms, each electromagnetic waveform having a leading edge, the method comprising:

selecting a wire of the set of wires to define the wire as a wire under test while coupling the remaining wires in the set of wires to ground;

charging a capacitance defined between the wire under test and the remaining wires using a current source; and

finding one of the remaining wires that causes a parallel arcing fault to occur between the wire under test and the one of the remaining wires by using a sequencer to selectively uncouple each wire of the set of wires or couple each wire of the set of wires to the current source or ground.

26. The method of Claim 25, wherein the act of finding includes uncoupling the remaining wires in the set of wires when a parallel arcing fault occurs.

27. The method of Claim 26, wherein the act of finding includes coupling one wire of the remaining wires to ground while floating the rest of the remaining wires and reexecuting the act of charging to repeat the occurrence of the parallel arcing fault.

28. The method of Claim 27, wherein the act of finding includes iterating the acts described in Claim 27 until the method finds the wire in the set of remaining wires that causes the parallel arcing fault to occur between the wire under test and the wire in the set of remaining wires.

29. The method of Claim 28, wherein the act of finding includes concluding that the parallel arcing fault occurs from the wire under test to a frame of a vehicle if the act of iterating cannot find the wire in the set of remaining wires that causes the parallel arcing fault to occur.

30. The method of Claim 27, isolating the wire under test and the wire found by the act of iterating by coupling the wire under test to the current source and coupling the wire found by the act of iterating to ground while floating all other wires of the set of wires.

31. The method of Claim 30, further comprising: calculating the distance to the parallel arcing fault by re-executing the act of charging to cause the parallel arcing fault to occur.

32. A device for detecting and locating parallel arcing faults in a set of wires, each parallel arcing fault radiating electromagnetic waveforms, each electromagnetic waveform having a leading edge, the device comprising:

two or more receivers, each receiver including an antenna being receptive to one or more impulses that are caused by one or more leading edges of one or more electromagnetic waveforms, each receiver being adapted to convert each impulse into a digital pulse; and

a controller electrically coupled to the two or more receivers and being receptive to a first digital pulse from the two or more receivers at a first point in time and a second digital pulse from the two or more receivers at a second point in time, the controller being adapted to calculate a distance to the parallel arcing fault by determining the difference between the first point and the second point in time, the sign of the difference being indicative of the direction of the parallel arcing fault.

33. The device of Claim 32, wherein the two or more receivers are coupled to the controller via two or more coaxial cables, each coaxial cable having a length being proportional to the length of another coaxial cable.

34. The device of Claim 32, wherein the two or more receivers are made responsive only to leading edges with a rise time less than a predetermined limit.

35. The device of Claim 32, wherein the controller is located equidistant between the two or more receivers, and wherein the distance to the parallel arcing fault is calculated from the position of the controller.

36. The device of Claim 32, further comprising: an impulse transmitter being coupled to the controller for determining an offset so as to calibrate the distance from the controller to the parallel arcing fault.

37. The device of Claim 32, further comprising a user interface device being electrically coupled to the controller, the user interface device including a display and a keyboard.

38. The device of Claim 32, wherein the controller has a printer output and a communications port for coupling to a computer.

39. A method for detecting and locating parallel arcing faults in a set of wires, each parallel arcing fault radiating electromagnetic waveforms, each electromagnetic waveform having a leading edge, the method comprising:

converting into multiple digital pulses from multiple impulses that are caused by multiple leading edges of multiple electromagnetic waveforms, the multiple impulses being received by multiple antennas of multiple receivers;

receiving by a controller a first digital pulse from a first receiver at a first point in time and a second digital pulse from a second receiver at a second point in time; and

calculating a distance to the parallel arcing fault by determining the difference between the first point and the second point in time, the sign of the difference being indicative of the direction of the parallel arcing fault.

40. A device for detecting and locating parallel arcing faults in a set of wires, each parallel arcing fault radiating electromagnetic waveforms as well as ultrasonic emissions, the device comprising:

an ultrasonic receiver having an electrostatic transducer for receiving a sonic pulse from the ultrasonic emissions at a first point in time;

an antenna for receiving a leading edge of an electromagnetic pulse from the electromagnetic waveforms at a second point in time; and

a controller electrically coupled to the ultrasonic receiver and the antenna, the controller calculating a distance to the parallel arcing fault by determining the delay between the sonic pulse at the first point in time and the leading edge of an electromagnetic pulse at the second point in time.

41. The device of Claim 40, further comprising a laser pointer to point in the direction in which sonic pulses have high signal strength, thereby locating the direction of the parallel arcing fault.



42. A method for detecting parallel arcing faults in a set of wires, the voltage at which a parallel arcing fault occurs being below a predetermined test voltage level, the method comprising:

selecting a first wire of the set of wires and defining the first wire as a wire under test while grounding the remaining wires in the set of wires to define these remaining wires as ground wires;

charging a capacitance defined between the wire under test and the ground wires using a current source until the voltage on the wire under test ramps up to the predetermined test voltage level;

providing an arc sensing means responsive to the occurrence of an arc discharge;  
and

determining that a parallel fault exists if said arc sensing means indicates the occurrence of at least one arc discharge.